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Educational buildings relate to their environment in many ways that affect the surrounding community such as overall appearance, energy consumption, and waste production. This report examines these issues and identifies how educational buildings can contribute to the conservation and protection of the environment. It explores these issues in three types of schools: healthy schools; green schools; and energy-conscious schools. Concluding comments summarize the findings and presents conclusions. (GR)

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Report of an international seminar
organised by the OECD Programme on Educational Building (PEB)
in co-operation with the Austrian Ministry of Education and Art and the
Austrian Institute for School and Sports Facilities

PEB

by Dr. Rupprecht Ottel

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DECENTRALISED PROGRAMME ON EDUCATIONAL BUILDING

EDUCATIONAL BUILDINGS AND THE ENVIRONMENT

Report of an international seminar organised by the OECD Programme on Educational Building (PEB) in co-operation with the Austrian Ministry of Education and Art and the Austrian Institute for School and Sports Facilities

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FOREWORD

The OECD Programme on Educational Building (PEB)

The Programme on Educational Building (PEB) operates within the Organisation for Economic Co-operation and Development (OECD). Since its inception in 1972, PEB has promoted the international exchange of ideas, information, research and experience in all aspects of educational building.

PEB's priorities respond to the changing emphases of educational policy within participating countries. The overriding concerns of the Programme are to ensure that maximum educational benefit is obtained from past and future investment in educational buildings and equipment, and that the stock of facilities is planned and managed in the most effective and efficient way.

The three main themes of the Programme's work are:

- improving the quality and suitability of educational facilities and thus contributing to the quality of education;
- ensuring that the best possible use is made of the very substantial sums of money which are spent on constructing, running and maintaining educational facilities;
- giving early warning of the impact on educational facilities of trends in education and in society as a whole.

The report

Educational buildings relate to their environment in a number of different ways. By their design and appearance they can enhance, or detract from, the area which they serve. They consume significant amounts of energy, and generate waste. The materials of which they are constructed, and the technologies used in running them, may have a physical and a psychological effect both on those who use them, and on the surrounding area. They can be a potent tool in the environmental education of children and adults.

This report looks at some of these issues and seeks to identify how educational buildings can contribute to the conservation and protection of the environment. It is based on the discussions and conclusions of an international seminar in Vienna in 1992 which was organised by the OECD Programme on Educational Building (PEB), in cooperation with the Austrian Ministry of Education and Art and the Austrian Institute for School and Sports Facilities. The author, Dr. Rupprecht Ottel, is a professor of Architecture and Civil Engineering in Vienna. The opinions he expresses are his own and do not necessarily represent those of the authorities concerned or of the OECD.

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CONTENTS

Introduction 7

Healthy schools 7
- Issues 7
- Discussion 8
- Conclusions 11

Green schools 12
- Issues 12
- Discussion 12
- Conclusions 13

Energy-conscious schools 14
- Issues 14
- Discussion 14
- Conclusions 17

Summary of conclusions 18

Bibliography 20

INTRODUCTION

How school buildings affect their environment

This report is about school buildings and their relationship with their environment. Schools provide the physical surroundings in which children learn and adults work. Their design and construction will reflect their age and situation, but whatever form they have they must, first of all, be healthy and safe places for pupils and teachers. Secondly, they are a part of the built environment, and as such they consume energy, create waste and have a visual and physical impact on the areas where they are sited. Finally, they are in themselves an element of children's formative experiences. They should be designed and managed in such a way as to minimise their detrimental effects and to contribute to the environmental and aesthetic education of those who use them.

About 70 participants from 20 countries attended the seminar from which this report draws its material. They brought together a wide range of expertise, and represented a rich variety of educational systems. The report does not however represent an agreed set of conclusions to which all the participants would necessarily subscribe. It is, rather, a personal view, which draws on the wealth of information and experience made available at the seminar.

The issues discussed are presented under three headings:

- healthy schools,
- 'green' schools,
- energy-conscious schools.

HEALTHY SCHOOLS

Issues

Good health is of paramount importance to the individual and to society. The claim that "a well-designed school is a healthy school" not only makes common sense, but has been substantiated in surveys carried out among schoolchildren and through research. Feeling good and keeping healthy at work depend to a considerable extent on the building one occupies. Schools, where young people are obliged by law to spend a substantial part of their formative years, must be exemplary in the standards to which they adhere and the practices which they adopt.

Important contributory factors to a feeling of well-being are the external appearance of the building, the proportions and layout of rooms, the materials used in construction, the colour scheme, natural and artificial lighting, indoor climate and acoustics. Every opportunity should be used in new buildings and during maintenance and renovation work on existing buildings to improve the quality of facilities, to use local, environmentally friendly and safe materials, and to aim for solutions which minimise the consumption of raw materials.

These are very general requirements, and their implementation gives rise to many practical questions. Among these are:

- Which are the factors which have the greatest impact on the quality of life and learning?
- What are the relative costs of different courses of action, and are they worth while?
- What advice is available to assist designers and planners in the choice and use of environmentally friendly and economically efficient materials?
- How can resources be used most economically during the construction of a building?

- Is it possible to define standards for the indoor climate, air quality, lighting, and acoustics?

Discussion

In seeking to clarify the concept of a "healthy school", a distinction can be drawn between the psychological and physiological aspects.

i. Psychological aspects

A school should provide a pleasant working environment. Where the surrounding buildings are attractive and in good condition, the school should match them; where the surroundings are uninspiring and in poor condition, the school should stand out as a haven of quality. The tendency towards ever larger schools, justified on economic rather than educational grounds, results in children having to travel further to school, often by bus or other means of transport. In many places the school has lost its place as the heart of the community, while energy consumption and environmental pollution have increased.

The nature of the local environment is an important factor in the atmosphere of a school. Air quality, the landscape, the built environment and social conditions all contribute. Protection against noise and dust is sometimes still necessary in towns, while in rural areas with good environmental conditions, such protection may be less necessary. A school should be designed to take account of the local climate, local construction materials and local types of building, and thereby contribute to regional culture.

A clear layout and a warm, pleasant environment inside the school should be regarded as minimum requirements. Surveys carried out amongst pupils have established that the architecture of school buildings has to meet certain basic social needs. Pupils react to their surroundings and use a wide range of adjectives to describe different facilities—cold, characterless, uninspiring, aggressive, warm, soft, oppressive, liberating, friendly, inviting, attractive, showy, protective, and so on.

Heavy, oppressive ceilings on weak-looking pillars should be avoided, as should aggressive gloss paint, the juxtaposition of unrelated colours and shapes, sharply drawn boundaries and spaces without windows. Wide vistas, light-toned varnishes, markings pointing the way into the premises and the merging of structural elements in warm colours are all desirable for a healthy school.

Psychological research in Germany

An attempt has been made through psychological research in Germany to explain these general concepts and give them a practical bearing. According to the research, school buildings can have a pleasant, engaging effect on pupils only if they are attuned to the particularities of the human sensory system, in particular to their sense of equilibrium. This sense is irritated by sloping edges and soothed by perpendicular and horizontal edges. The presence of sloping edges in buildings triggers compensatory eye movements which may create a subjective impression of something interesting and stimulating, but an unpleasant and threatening feeling when the sense of equilibrium is greatly irritated. Too many stimuli create feelings of irritation, excitement or danger, while too few can lead to boredom.

A glass-roofed space at the University of Trondheim

In order to promote social interaction in schools, it is possible to learn from the narrow streets found in many older, European city centres. In modern buildings, the use of glass roofing over courtyards and small squares can create spaces which are protected from the weather and can be used as recreational areas.

A glass-roofed pedestrian area in the University of Trondheim gives an example. The windows of the adjacent premises look onto this area. The escape routes from the buildings which originally led into the open have been connected through basement corridors with other exits. The glass-roofed area is not heated; the temperature in winter is roughly 10°C. The heat insulation on the walls of this glass-roofed area can be reduced; sound-absorbent material is necessary to reduce noise. Often, the roof can be kept open in summer. Cleaning the glass roof presents few problems, since most of the dirt is carried away by rain and snow.

A survey has shown that this area has been well accepted, especially by the students. None of the 253 respondents expressed a negative opinion. More than two-thirds were satisfied with the lighting and temperature levels. Noise levels were described as more stimulating than disturbing. The glass-roofed passageway had intensified social contacts, was used for many purposes and had revitalised surrounding areas.

ii. Physiological aspects

In the past thirty years, many new building materials have been marketed. Inevitably, little was known at the time about their long-term effects. Their dangers are often discovered only after they have been widely used. The best-known example is certain types of asbestos, which present a severe health risk when they begin to deteriorate. The treatment or removal of asbestos in school buildings has been estimated to cost over $3 billion in the United States alone, and the phenomenon has been repeated in other OECD coutries. More recently polychlorinated biphenyl (PCB—used in paint, lacquers, and glues), has been identified as giving rise to similar problems.

According to the European Community Council Directive Relating to Construction Products (89/106/EEC), "Member States are responsible for ensuring that building and civil engineering works on their territory are designed and executed in a way that does not endanger the safety of persons, domestic animals and property, while respecting other essential requirements in the interests of general well-being".

The Directive specifies the main requirements as regards hygiene, health and the environment in quite general terms:

> *Construction work must be designed and implemented in such a way that it will not be a threat to the hygiene and the health of the occupants or neighbours, in particular as a result of any of the following:*
>
> - *the emission of toxic gas,*
> - *the presence of dangerous particles or gases in the air,*
> - *the emission of dangerous radiation,*
> - *pollution or poisoning of the soil,*
> - *faulty elimination of waste water, smoke, solid or liquid wastes,*
> - *the presence of damp in part of the works or on surfaces within the works.*

If these rules are strictly interpreted, many building materials that are now commonplace will have their use severely restricted.

Restrictions on building materials in Germany

In Germany construction materials have been assessed with regard to pollutant emissions, radioactivity, primary energy consumption, pollution during manufacture and re-usability in order to help planners reach decisions. Regulations have been formulated on the prevention of formaldehyde concentrations in the air from the use of particle boards, limits to formaldehyde emissions for the use of foam products, the improvement of weakly bound asbestos products and wood protection in buildings, and restrictions have been introduced on the use of aluminium, asbestos, formaldehyde, CFC, urea-formaldehyde foam products, hydrazine, isocyanate, lindane, polychlorinated biphenyl (PCB), pentachlorophenol (PCP), perchlorethylene, polyurethane, polyvinyl chloride (PVC) and mineral tar oil.

In Berlin financial assistance for building projects is in principle ruled out if any of the following are used: construction materials containing asbestos, building components made of tropical woods, foam softboard and foam products using polyurethane and chlorofluorocarbons, extruded polystyrene board, window and door frames made of PVC or aluminium, floor surfaces, wallpaper and small building components made of PVC, and ground, mains and waste pipes made of PVC.

Recycling of building waste

In Austria, since 1993, building waste is separated, collected, and if possible recycled. Contractors are required to sort waste material into the following categories:

- excavated material,
- asphalt rubble,
- plastics,
- metals.
- concrete rubble,
- wood (unpainted),
- mineral waste such as bricks, mortar, plaster work,

Excavated material can be re-used elsewhere, and concrete is re-used especially in road building, as is asphalt rubble. Bricks present a problem since they are not frostproof when broken; plaster is sensitive to water and has to be treated carefully because of the chemical components. Storage of material until it can be re-used also requires care because of potential groundwater pollution. Some items, such as wooden window-frames, cannot be re-used. It is estimated that the cost of separating building waste amounts to some 3 per cent of total building costs.

Checks and tests are also necessary in existing schools. Air quality is particularly important, since increasing numbers of pupils suffer from asthma and allergies. The cost of replacing and looking after a teacher who falls ill can be far more, for example, than that of the energy needed for good ventilation.

Indoor air quality

In Maryland, USA, complaints by the school management about light, noise, dust or odours are grounds for more thorough tests. In the case of a complaint, a four-step procedure for building inspection is implemented.

This procedure begins with a visual survey of the building site and the general characteristics of the building (e.g. total gross square feet, number of stories, structure type...). A general room-by-room check is then carried out for items such as the accessibility of filters and the proper drainage of condensate pans. The third step involves taking measurements during specific room surveys. The quality of the air in schools is measured (temperature, dampness, CO^2 content, fresh air rate, air speed and the outside air conditions as a further check), and the state of the heating and ventilation systems is described. The checks and measurement lead to a report stating the ways and cost of resolving the problems found, and giving possible recommendations for subsequent actions to be taken.

- It is difficult to define a "healthy school" and in this context a distinction between mental and physical health must be made.

- Local climatic conditions will determine to a considerable extent how the buildings will be designed. For example, in some circumstances there is no practical alternative to air-conditioning. However there is a great deal of experience of appropriate design and materials which enable schools to resolve problems caused by climatic conditions—sunlight, rainfall, wind, extreme temperatures—without recourse to expensive mechanical systems which may carry attendant health risks if not adequately maintained.

- In the case of mental health, architects need to show more understanding of teachers' and pupils' needs. More research is needed on the characteristics of pupils and the effects of building design on them.

- Teachers and pupils should be included in the design and planning process: their task is not necessarily to specify how things are to be done, but they should be able to express their requirements and to have a say in what is to be done. They should be made aware of the constraints, so that false hopes are not raised. Parents can also be included in planning and in the design process, while the experts remain responsible for the architecture and creating an entity in harmony with the rest of the environment. If people are offered a genuine opportunity to contribute to the process—whether it be for new building or for renovation—then they will understand the solution proposed, and will be more likely to accept it, even when it does not fully meet their expectations. They may also be better able to make use of the facilities provided.

- A locality which produces favourable environmental conditions is very important from the physical health viewpoint. Clearly construction materials must not be harmful, but there is still too little accurate information on this subject, and sometimes the dangers of new materials are not realised until it is too late. There should therefore be a predisposition to use more natural construction materials such as wood, brick, ceramics, linoleum, where these meet the requirements and are available. Although the initial costs may appear to be higher, these materials do not need much energy to produce, are very durable, and can be easily maintained.

- Schools should be designed and built for a long service life and be kept in good condition in order to minimise deterioration and discourage damage by pupils. Materials should be examined critically and the possibility of recycling them taken into account. The outer shell of a building will depend on the particularities of the regional climate; priority should go to materials that are used locally and are easy to obtain.

- Interior construction materials will be chosen for the feeling of comfort and well-being they create. Again, there is too little information on the detrimental effects which many materials may have on users as a result of their chemical components or radioactivity. There is a need for information to be collected and made available internationally on this subject, to provide an objective and reliable source of advice to authorities. It must be ensured that any limitations laid down are based on a realistic assessment of the danger, and that excessive demands, which cannot be met, are not made.

- Technical systems should be judged according to their capacity to promote better health and comfort, and their potentially harmful aspects should be evaluated.

GREEN SCHOOLS

Issues

Few would dispute that schools should be healthy places, but the notion of a 'green' school is less widely recognised. However, educational institutions, especially schools, provide a uniquely influential opportunity for environmental education. The building in which children spend a substantial part of their early years will have a lasting influence on them. A 'green' school is one which is integrated with its environment—urban or rural—in such a way that children can have contact with nature, and can begin to understand some of the issues involved in environmental education.

The use and layout of external areas—school yards, recreation areas, school gardens and biotopes—should make it possible to observe the changing seasons, and should provide opportunities to observe the life-cycle of plants and animals. Nature should be tangible, meaning that there should be no inaccessible, fenced-off flower beds or "keep off the grass" signs, while green space along with paved open areas should be available for many kinds of use. In built-up areas, green space such as parks, avenues and gardens could be extended into school grounds to form part of a functioning, living, breathing urban entity. This would imply that the public, parents and pupils would have to treat these amenities with care and take an active interest in their upkeep.

The OECD's Centre for Educational Research and Innovation is engaged in a project on 'Environment and school initiatives'. Among other aspects of environmental education it addresses the issue of student awareness. A list of documents available is included in the bibliography.

Discussion

Very few schools are situated in environments which naturally lend themselves to a study of nature and the environment. Many have restricted sites, and even where substantial areas of land are available these are frequently devoted to sport. However pioneering work has been carried out in the United Kingdom to increase public awareness of the potential of school grounds.

United Kingdom

"Learning through landscapes" was established in 1990 to advise schools about how to make good use of their sites, however small. The UK has about 30 000 schools and of these so far about 6 000 have consulted the organisation. Some of the work of the project is described in more detail in Annex. In 1991, Sweden set up its own organisation on the same model.

The project has noted that fencing often creates a feeling of imprisonment, that playgrounds frequently have hard concrete surfaces, and that buildings and open areas are seldom conceived on a scale suitable for children. It proposes the inclusion of the natural environment: meadows, ponds, bushes and trees within the school grounds, and it demonstrates how beneficial such an environment can be for a school. Even in urban areas, children can get to know about grasses, plants, insects and animals. Domestic animals can be kept and can contribute to learning.

Research in the United States has found that there is some correlation between the quality of the physical environment and the quality of individual's work and personal satisfaction. Students work best and make the greatest progress if they can participate actively in the organisation of the facilities. A school should not form a sterile or rigid environment, but should be constructed and laid out with a variety of surfaces and colours, reflecting regional particularities and culture.

Examples of how pupils can involve themselves with their local environment abound. In a world in which the impact of human action is not always

predictable, and in which decisions have to be taken in the face of conflicting information, such activities have many advantages. They can encourage pupils to take responsibility for their own actions, to exercise influence on social processes, and to acquire and implement knowledge about their environment. Through such actions pupils identify themselves with their schools. They have the chance to be creative, rather than destructive. Vandalism often decreases where projects such as those described below are undertaken.

Environmental education in practice

At a school in Austria pupils carried out a survey of energy use in four nearby villages. Data was collected from households using a questionnaire, processed, and analysed. Proposals for savings were made to those interested. The pupils learned about their environment, and also about different points of view on the need to reduce consumption. They were able to provide useful information, and contribute to community development.

In another case, after analysing energy consumption in a school, teachers and pupils installed a thermostat, carried out insulation work and created a winter garden.

A high school in Berlin studied the pattern of energy consumption in the building, worked out and helped implement proposals to reduce it, and thus contributed to a 20 per cent reduction in fuel oil consumption.

Again in Austria, in a 1960s school which had a very poor image, pupils painted and refurbished two spare classrooms in their own time and with their own money. In succeeding years, these rooms were much better looked after by the pupils themselves than the other non-renovated classrooms. Then pupils worked out a plan for the redesign of the school yard, turning the bare concrete surface into two areas for sport and recreation, separated by a mound.

Conclusions

The nature of the school environment varies both within countries (urban and rural; different climatic conditions) and between countries (some provide extensive grounds, others do not). Although it is not possible to prescribe solutions it is worth noting that school grounds present an opportunity for environmental and other studies on which many schools are failing to capitalise. Wherever man intervenes in nature, for example to build a school, he contributes to the destruction of the natural environment. The simple possibilities of using the grounds to improve working conditions for teachers and pupils, and to establish the school as an example of how human activity can protect and enhance the environment, and contribute to its protection, are of great potential value.

- The school's environment should have an impact on pupils; accordingly they must be allowed to take an interest in it and should have the opportunity of planting and seeing things grow. They should if possible be able to observe a natural feature, such as a pond or stream. They might also be able to help look after this amenity, although attention has to be paid to the risks involved, particularly for very young children. Keeping animals, although it may be highly beneficial educationally, raises problems about who will look after them during weekends and holidays. Moreover, many children are allergic to animals and it may well be simpler and better to visit farms and other places where animals can be observed.
- Open-air sports facilities are provided in schools in many countries. Increasingly grass fields have been replaced by synthetic surfaces in order to maximise the usage that can be made of them, but these surfaces are, from the environmental point of view, 'dead'. It is recommended that where artificial

surfaces are used efforts should be made to plant grass, trees or shrubs on the areas between pitches.

- Diversity and harmony are desirable characteristics for external areas; gardens can be planted on flat roofs, as well as between sports fields.
- Care should be taken that the school damages or pollutes the environment as little as possible. Waste should be sorted and recycled; drinking water should be separated from industrial water.
- Children need to be able to identify with their school, or at least with some areas of it. Participation in some of the decisions which affect them, such as redecoration or furnishing, will foster this sense of identity, and can be expected to reduce vandalism.
- Energy savings and environmental problems should be incorporated in the teaching programme.
- Today's children are tomorrow's adults. If they see that their school is careful with energy and the environment, then they may act correspondingly in later life.

ENERGY-CONSCIOUS SCHOOLS

Issues

Energy conservation has been on the policy agenda since the early 1970s, mainly because of the need to reduce expenditure on energy. Much technical progress has been made in reducing consumption of non-renewable fuels. More recently attention has turned to the polluting effect of primary energy consumption and many environmental protection policies in industry, commerce and transport are aimed at reducing pollution. Similar measures should be introduced for educational buildings.

The conclusions of an earlier PEB seminar on "The will to manage energy in schools" state that:

> *Unless people with improved technical skills can be employed to operate efficient and reliable equipment installed in well-designed, sophisticated buildings, the view can be taken that schools should be built which depend on natural conditions and use local resources in construction.*

Buildings must not become over-technical machines which only specialists are able to understand, and whose efficient operation is dependent on high levels of staff, energy and maintenance expenditure. So far as possible the building should be self-sufficient. This will mean making optimal use of its location, the availability of sunlight, insulation and thermal capacity, prevailing winds and natural ventilation. Every kilowatt of energy saved is a contribution to the protection of the environment. The characteristics of the building shell, the adjustment of services and the minimisation of heat loss through ventilation are the main factors in conscious energy management.

Discussion

There is a plethora of regulations and advice on energy saving. Austria, for example, has a series of provisions and instructions on heat insulation, including the federal provisions which are valid throughout the country, and regional regulations which vary considerably from one part of the country to another. There are also instructions on room temperature, heat insulation, heat retention and lighting which are specific to school buildings.

The aim behind these provisions is to improve the insulation of buildings and thereby to save energy. However, existing buildings often fail to meet new

requirements since many have been constructed with materials which do not, and cannot, meet them, and according to designs which do not lend themselves to energy conservation.

Directives are currently applied to individual building components, but this approach has been questioned. Some feel that it might be better to specify a maximum heat loss target for a building and allow the architect to decide how to meet it.

Another consideration is that the service life of a modern school building, and in particular of its heating and ventilation systems, is only 15 to 25 years. More traditional design demands less complicated systems, and consequently lower maintenance costs. During short periods of extremely cold outside temperatures, there will be less need to boost heating, since solid buildings react only very slowly to changes in temperature. Similarly in summer, the more solid building will stay cool longer than a lighter one and will therefore be more comfortable to work in.

Typically, a school's energy consumption might break down in the following way: 2.5 per cent for water, 15 per cent for heating, 32 per cent for electricity,

Austrian practice

The Austrian Institute for School and Sports Facilities (ÖISS) and the Federal Ministry for Education and the Arts (BMUK) specify a working temperature for classrooms of 20°C. A lower ambient temperature (for example 18°C) could give rise to substantial energy savings in winter, since the rate of energy loss depends on the difference between inside and outside air temperature.

In addition to winter temperatures, room temperatures in summer should also be taken into account. As early as 1975 ÖISS had established guidelines on designing buildings in such a way as to avoid excessive solar gain and to favour ventilation, and yet to maximise heat retention when necessary. The intention was to avoid wherever possible the use of mechanical ventilation and air-conditioning systems with their high purchase and operating costs. At the time only a rough estimate could be given for the heat retention capacity of a building. Today computer programs for calculating the retention capacity needed to control room temperatures in summer without air-conditioning systems are contained in ÖNORM B8110. There are two trends in construction to meet these requirements at present: on the one hand massive structures which retain heat and use windows for ventilation and, on the other, light structures with mechanical ventilation and heat recovery in winter. The future will show which of these two systems proves more efficient.

Research has been carried out on heat retention involving measurements of the internal and external environment (ambient temperature, radiator temperature, inner and outer surface temperatures of the walls, outside air temperature, temperature when the windows are open, when the lights are on or when the blinds are down, relative humidity). In schools with massive structures, and consequently high heat retention capacity, there is little correlation in winter between outer air temperature and inner air and surface temperatures. Schools with a lighter structure exhibit strong correlations in summer between inside and outside temperatures.

In principle, natural lighting is to be preferred for classrooms, although there are no precise rules about sunlight and the daylight ratio. The question arises here of whether priority in the future should go to natural lighting which will imply use of relatively large windows, thus leading to greater heat losses in winter, or to predominantly artificial lighting with small windows or no windows at all, which minimise heat losses in winter and permit the use of compact, energy-efficient structures.

In Austria educational authorities have learned from experience that teachers and pupils prefer old buildings, those erected before 1914. New buildings with expensive technical systems are less popular. The authorities have therefore concluded that they should rely less on technical systems and more on the design of the building to regulate indoor climatic conditions. In Lower Austria a school has been built to the specifications used in the year 1913, i.e. with solid brick walls, a pitched roof and plenty of space. The users express greater satisfaction with this "old-fashioned" school building than with "modern" school buildings.

30 per cent for cleaning and 20 per cent for utility system maintenance. Heating costs can be reduced by 25 to 30 per cent simply by controlling the temperature in individual rooms, without recourse to sophisticated techniques. However, the controls should be out of pupils' reach, or be otherwise protected against vandalism.

Applying general standards to the specific case of school buildings is often unnecessary because of the times during which schools are open. For instance, a fresh air flow of 8 000 cubic metres per hour is required in ÖNORM B2608 for gymnasia. But this is really necessary only in the hot summer months, when schools are usually on holiday. For schools, 3 000 cubic metres per hour is generally sufficient.

Teachers' behaviour is a very important factor when it comes to reducing energy costs. If it is not possible for a teacher to quickly and simply regulate the temperature in the classroom, then he or she may be likely to open the window if the room gets too hot.

Monitoring can identify when equipment is being used. Checks during the holidays also frequently reveal that windows have been left open, or that rooms are being ventilated during holidays. In one school the entire heating system was left running during the summer in order to provide hot water for cleaning. A separate boiler would have led to substantial savings.

Developments in the United Kingdom

In the United Kingdom, guidance has been available since 1981 on energy savings by means of natural lighting, natural ventilation, the use of solar energy and a good heating-control system. England was the first country (in 1961) to build a school heated entirely with solar energy. In the past few years these ideas have been increasingly applied and a number of schools are now using solar energy.

Natural lighting is important since electricity accounts for over 40 per cent of a schools' energy consumption, and electricity consumption has risen greatly in the United Kingdom in the past few years. The aim with natural lighting is to achieve a minimum daylight factor of 2 to 3 per cent at working-surface levels.

In the United Kingdom, artificial ventilation may account for up to 50 per cent of energy consumption in schools. Accordingly, greater importance is now being attached to natural ventilation in which air is changed by means of high roof lights or ventilation shafts.

These energy-saving principles have to be applied, however, not only to the few new schools being built but also to the approximately 25 000 existing schools. These schools must be renovated from time to time; and this provides an opportunity for action to be taken to save energy, depending on whether walls, roofs, windows or heating systems are being renovated. In the case of schools built in the 1960s and 1970s the window areas, which amount to up to 70 per cent of the external wall area, are often reduced to 35 per cent, with upper windows being kept for classroom lighting. These energy-saving measures also contribute to a reduction in carbon dioxide emissions and to the maintenance of a healthy environment.

Bioclimatic design in Greece

The following example is that of a school in Andros, Greece, which tries to reflect both local architectural tradition and the principles of bioclimatic design. The 1600m^2 building occupies a flat site, and is positioned away from other buildings that might shade it. It consists of two wings joined by an auditorium. The building has two storeys, and contains six classrooms, a library, a laboratory, offices and the auditorium on the gound floor, and four classrooms on the first floor. It is laid out on an east-west axis. In this building the classroom windows face south and classroom lighting is natural. The windows take up about two-thirds of the width of the outer walls. Trombé walls with an ancillary shell incorporate ventilation apertures that can be manually operated to provide cross-ventilation in summer. Solar collectors on the auditorium roof provide the heat required in winter. The school benefits from an average of 2895 hours of sunshine a year.

The situation in former East Germany

Attempts are being made in Germany to renovate school buildings in the länder which were formerly part of the German Democratic Republic. Schools built before 1914 are still mostly in a satisfactory condition. Buildings erected between then and the mid-1960s are usually well-built, brick buildings with steep roofs and good heating characteristics. Schools built after 1965 present a problem: there are about 2 500 of them (representing over 50 per cent of the stock) for which a construction method using prefabricated panels had mainly been used. Since there were only a small number of basic models used for these schools, renovation measures that can be broadly applied are being considered for each basic type. The courtyards of some of these schools could, for example, be covered, thus dispensing with the need to renovate the courtyard facades. Where additional staircases and/or classrooms are necessary, they are to be built on in such a way as to reduce the outer wall area and to provide a more compact building. A high proportion of the windows has to be changed, since at present about 40 per cent of them are single-paned.

With the help of these measures the current energy consumption of 300 kWh per square metre of gross floor area per annum is to be reduced to about 60 kWh/m^2/year. If, in addition, transparent or opaque insulating material is used on the outer walls of buildings, it may be hoped that annual energy needs for heating can be reduced to less than 50 kWh/m^2 of useful area. A test structure with such heat insulating materials is now being prepared.

Conclusions

- Different viewpoints were expressed concerning the need for standards and regulations; some advocate more precise rules, others greater freedom. It was proposed that standards should concentrate on essentials, not restrict progress and be attainable. It should be possible to obtain advice from neutral agencies.
- With regard to room temperature, it was noted that different countries recommend different values, i.e. the UK 18°C, and Italy and Austria 20°C, that some countries differentiate between ambient temperatures in classrooms and other rooms, and set the ambient temperature for corridors and halls at 15°C. It is advocated that existing recommendations should be reviewed.
- Natural ventilation for classrooms should be preferred as far as possible, since it results in lower investment costs, lower energy consumption, lower environmental pollution and lower maintenance costs. Examples from the United Kingdom show that rooms up to nine metres deep can be naturally ventilated. On the other hand, heat recovery from ventilation is feasible only with mechanical ventilation systems. It is generally recommended that, in European climatic conditions, air conditioning and mechanical ventilation systems should be installed only in specific cases.
- The human factor is important, and centralised management may be disadvantageous; it is better to give the school decentralised budgetary responsibility, and the incentive to make savings on energy.
- Most countries have specifications for the minimum window area in classrooms. An international regulation would not be possible since lighting conditions differ too greatly. Apart from hot regions such as the Mediterranean, Africa or the southern parts of the United States, natural lighting should be preferred in classrooms, but protection against the sun and glare is necessary. Although skylights give good lighting possibilities, they do have disadvantages in terms of overheating and burglary risk.
- The psychological aspects of windows must be taken into account, since it is important to be able to see outside. This necessity can be disregarded only in rooms in which windows disturb teaching, e.g. when visual aids are frequently used.
- Experience in the last few years has shown that as a rule it is more economic to improve existing buildings and renovate their heating systems than demolish and re-erect them. With improved roof insulation, smaller window areas, blocked-up windows, new burners, new boilers, control systems and replacement of the hot water system, substantial energy savings can be made.

SUMMARY OF CONCLUSIONS

- It is difficult to define a "healthy school" and in this context a distinction between mental and physical health must be made.

- Local climatic conditions will determine to a considerable extent how the buildings will be designed. However it is possible to resolve problems caused by climatic conditions without recourse to expensive mechanical systems which may carry attendant health risks if not adequately maintained.

- Architects need to show more understanding of teachers' and pupils' psychological needs.

- More research is needed on the effects of building design on pupils.

- Teachers, pupils and parents should be included in the design and planning process. Genuine consultation will improve the project, and ensure that it is better used and cared for.

- There is still too little accurate information about the risks attached to certain building materials.

- Natural materials are to be preferred if there is any doubt. Although their initial costs may appear to be higher, these materials do not need much energy to produce, are very durable, and can be easily maintained.

- Schools should be designed and built for a long service life and be kept in good condition in order to minimise deterioration and discourage damage by pupils.

- Interior construction materials should be chosen for the feeling of comfort and well-being they create.

- Any limitations laid down on the use of certain materials should be based on a realistic assessment of the danger.

- Technical systems should be judged according to their capacity to promote better health and comfort, and their potentially harmful aspects should be evaluated.

- School grounds present an opportunity for environmental and other studies on which many schools are failing to capitalise.

- The school's environment should have an impact on pupils; accordingly they must be allowed to take an interest in it and should have the opportunity of planting and seeing things grow.

- Where artificial surfaces are used for sports and recreation, efforts should be made to plant grass, trees or shrubs on the areas between pitches.

- Diversity and harmony are desirable characteristics for external areas; gardens can be planted on flat roofs, as well as between sports fields.

- Care should be taken that the school damages or pollutes the environment as little as possible. Waste should be sorted and recycled; drinking water should be separated from water used for other purposes.

- Children need to be able to identify with their school, or at least with some areas of it. Participation in some of the decisions which affect them, such as redecoration or furnishing, will foster this sense of identity, and can be expected to reduce vandalism.

- Energy savings and environmental problems should be incorporated in the teaching programme.

- Today's children are tomorrow's adults. If they see that their school is careful with energy and the environment, then they may act correspondingly in later life.

- Regulations and standards should concentrate on essentials, and should be realistic. Authorities would value advice from neutral agencies.

- Currently recommended minimum temperatures for classrooms may in some cases be too high; and requirements for ventilation too strict, thus leading to unnecessary use of energy.

- Natural ventilation for classrooms should be preferred as far as possible, since it results in lower investment costs, lower energy consumption, lower environmental pollution and lower maintenance costs. Air conditioning should usually be seen as a last resort.

- Schools should be given the incentive to conserve energy, for example through decentralised budget management.

- Natural lighting should be preferred in classrooms, but protection against the sun and glare is absolutely necessary in some areas. Although skylights give good lighting possibilities in Northern latitudes, they can lead to overheating and can present a security risk.

- It is important to be able to see outside. This necessity can be disregarded only in rooms in which windows disturb teaching, e.g. when visual aids are frequently used.

- As a general rule it is more economic to improve existing buildings and renovate their heating systems than to demolish and re-erect them.

BIBLIOGRAPHY

Seminar papers

Abend, Allen. *Indoor air quality: Maryland Public Schools*

Bloedow, Hans-Joachim. *Energetische Sanierung von Schulgebäuden in den neuen Bundesländern* (English translation available: *Improving the energy characteristics of school building in the new federal länder)*

Castro-Rial Garrone, Amalia. *Schools and their different sitings in the Spanish landscape* (also available in French)

Cold, Birgit. *Indoor recreational places as glazed space*

Garcia Paredes, Francisco. *Guidelines for a healthy educational environment*

Graf, Eberhard. *Recycling*

Kleberg, John R. *Quality learning environments*

Lazzerini, Renato. *Ventilation and indoor air quality in educational buildings*

Leblebicioglu, E. Figen. *School and Environment*

Lucas, Bill. *The value of learning through landscapes*

Nesvadba, Ivan. *Energieverhalten in Schulbauten Realität-; Trends und Steuermaßnahmen* (English translation available: *Energy policy in school buildings: reality, trends and fiscal measures)*

Obadalek, Peter. *Behaglichkeitsmessungen in einer Klasse der Bundeshandelsakademie in Laa an der Thaya und des BRG XXIII in Wien sowie Vergleich der Ergebnisse*

Patel, Mukund. *Energy efficient schools in UK*

Posch, Peter. *Umweltinitiativen an der Schule*

Reinberg, Georg W. *Passive Solarnutzung im ökologischen Schulbau* (English translation available: *Passive use of solar energy in ecological school construction)*

Rittelmeyer, Christian. *Gesunde Schulen* (English translation available: *Healthy Schools)*

Schindler, Gerd. *Schule und Umwelt*

Tapaninen, Reino. *Healthy schools: some factors of a healthy school environment*

Wolf, Rudolf. *Gesundheitsgefährdende Baustoffe am Bau und in der Ausstattung von Schulen* (English translation available: *Health-threatening building materials in school construction and equipment)*

"Environment and school initiatives project"

Environment, Schools and Active Learning (OECD), 1991.

Posch, Peter. "Environment and School Initiatives", *ESI-Series No. 10* (OECD-CERI).

Reference to PEB report

The will to manage energy in schools (OECD-PEB) 1984.

Further reading

"Escape", *Learning through Landscapes Newsletter* (available from: Learning through Landscapes, 3rd Floor, Southside Offices, The Law Courts, Winchester SO23 9DL, United Kingdom).

"Energy Use in Educational Building", *Broadsheet 29* (DES, available from: Publications Centre, P.O. Box 2193, London E15 2EU, United Kingdom).